3D-printed biomaterials with regional auxetic properties.

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Public Summary:
We used our rapid 3D printing system to fabricate multi-layered, Non-Positive Poisson's Ratio meshes, integrating them into a single cell- supporting scaffold for tissue engineering applications. By utilizing the printing system's pattern flexibility, tiling functionality, and iterative speed, we were able to construct robust tissue-scale scaffolds with unique properties that were tunable through adjusting fabrication parameters. Our observations of unit-cell mesh actuation were consistent with numerical modeling, which helped tune the hinge and strut modifications necessary for proper scaffold actuation. Future work will be needed to optimize our auxetic meshes as a platform for stretch- mediated differentiation and eventually, facilitating tendon-muscle tissue regeneration.

Scientific Abstract:
Tissue engineering is replete with methods for inducing and mediating cell differentiation, which are crucial for ensuring proper regrowth of desired tissues. In this study, we developed a 3D-printed, non-positive Poisson's Ratio (NPPR) scaffold intended for future use in stretch-mediated cell differentiation applications, such as in muscle and tendon regeneration. We utilized dynamic optical projection stereolithography (DOPsL) to fabricate multi-layered, cell-laden NPPR scaffolds - these scaffolds can not only support aggregate cell growth, but can also be printed with locally-tunable force-displacement properties at length scales appropriate for tissue interaction. These NPPR multilayered mesh scaffolds can be embedded into highly elastic hydrogels in order to couple a reduced NPPR behavior to a normally Positive Poisson's Ratio (PPR) solid bulk material. This hybrid structure may potentially enable induced 'auxetic' behavior at the single-cell scale while tuning the Poisson's Ratio to a more isolated value. This would be uniquely suited for providing stretch-mediated effects for various cell-types within the tendon-to-muscle tissue transition.